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REVIEW ON PLANT: MORINGA OLEIFERA

Miss. M. Pavani, Dr. Jaya Shankar Reddy, Dr. C. Bhuvaneswara Rao, Dr. K. Venu Gopal

[1]Final year B Pharmacy, Krishna Teja Pharmacy college, Tirupati-517506.

[2]Professor and Vice Principal, Department of Pharmacology, Krishna Teja Pharmacy college, Tirupathi-517506.

[3]Professor and Head, Department of Pharmacology, Krishna Teja Pharmacy college, Tirupathi-517506.

[4]Professor and Principal of Krishna Teja Pharmacy College, Tirupathi-517506.

Abstract:

Moringa oleifera, commonly referred to as the "tree of life" or the "miracle tree," holds wide spectrum of medicinal and non-medicinal benefits, and so it is valuable herbal plant. M. oleifera has been traditionally use for treating various disease conditions such as wounds, pain, ulcers, liver disease, heart disease, cancer, and inflammation. Pharmacological studies have substantiated the hepatoprotective, cardioprotective, and anti-inflammatory potential inherent in extracts derived from various parts of the Moringa oleifera plant. Notably, bioactive constituents have been identified in every part of the plant, with over one hundred compounds characterized to date. The plant is rich in alkaloids, flavonoids, anthraquinones, vitamins, glycosides, and terpenes, among other things. Furthermore, the discovery of novel chemicals in the plant, such as niazimin A&B and muramoside A&B, has revealed potent hepatoprotective, anticancer, antihypertensive, antioxidant, and nutritional qualities. This current review underscores the traditional and remarkable advantages of Moringa, delving into its pharmacological characteristics, phytopharmaceutical formulations, clinical examinations, toxicity profile, and various other applications. Additionally, it aims to shed light on the plant's commercial and phytopharmaceutical applications with the intention of fostering further research. Despite this comprehensive exploration, the review acknowledges that many conventional uses of Moringa still lack scientific investigation. Consequently, the study advocates for further research to unravel the plant's mechanistic pathways, aiming to pinpoint and isolate the active or synergistic compounds accountable for its medicinal properties.

Key words:*Moringa oleifera, medical properties, antioxidant, anti-inflammatory hepatoprotective, nutritional qualities.*

Corresponding author:

M. Pavani,

Final year B Pharmacy,

Krishna Teja Pharmacy college,

Tirupati-517506.

QR code

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1.INTRODUCTION:

The tropical tree Moringa oleifera Lam., also known as the drumstick tree, belongs to the Moringaceae family. The native habitats of M. oleifera are mostly northwest India and Pakistan. At the moment, this species is extensively grown, mostly in India and a number of nations in Africa, South America, Asia, and the Middle East (Nelson and Rau, 2011). There are thirteen species in the Moringa family, and M. oleifera in particular has become well-known for its several applications in the production of biogas, nutrition, and fertiliser. Additionally, Moringa has a special ability to resist drought. In accordance to research, M. oleifera is a reliable and affordable choice for reaching the best nourishment (Chand and Anudeep, 2016). These days, its fruits, flowers, bark, seed, and roots are as utilized as raw materials in additional to the leaves(Vergara and Jimenez, 2017). M.oleifera is therefore utilized as a source of proteins, calories, minerals, and vitamins in underdeveloped nations. According to reports, dry leaves of M. oleifera have higher levels of calcium, magnesium, potassium, copper, iron, protein, carbohydrate, fiber, vitamin B, and calories than fresh leaves. Fresh leaves, however, have higher levels of vitamins C and E. Proteins, vitamins E, and magnesium have been discovered to be more prevalent in the seeds of M. oleifera than in the leaf, seed, or pod.(Gopalkrishna, 2017). Presenting a thorough overview of the latest information regarding M. oleifera's pharmacological activity, global research analysis, toxicological traits, plant chemicals composition, and ethnomedicinal qualities is the goal of the current review.

2.Morphology and toxonomy:

The tree grows rapidly in loamy and well-drained sandy soils, preferring a height of 500 m above level(Fuglie et al., 1998). Moringa oleifera has a deep taproot system, which allows it to access water deep within the soil. The trunk of moringa oleifera is typically straight the grow rapidly and can reach height 10-12 meters (Fahey et al., 2005). The leaves are pinnately compound with each leaf having 3-9 small, ovate to elliptical leaflets arranged along a central rachis. They are rich in nutrients, particulary vitamins A,C and E, and are commonly used for culinary and medicinal purposes (Anwar and Bhanger 2003). Moringa oleifera produces small, white to creamy-yellow flowers, which are fragrant and have five petals. The flowers grow in panicles that are typically 15-30 cm long. The fruits of Moringa oleifera which can grow up to 45 cm in length. The pods are green as they mature, containing numerous small, round seeds. The mature seeds, once harvested from the pod, are used for oil extraction which is known for its nutritional and cosmetic applications (Kumar and singh, 2012). Each pods contains 10-20 seeds that are flat and round, with a brownish, papery seed coat. The seeds contain about 30-40% oil, which is high in monosaturated fatty acids, making it valuable in both culinary and cosmetic products (Sivakumar and Srinivasan, 2011).

Table 1: Taxonomical classification

1	Kingdom	Plantae
2	Sunkingdom	Tracheobionta
3	Super division	Spermatophyte
4	Division	Magnoliophyta
5	Class	Magnoliopsida
6	Subclass	Dilleniidae
7	Order	Capparales
8	Family	Moringaceae
9	Genus	Moringa
10	Species	Oleifera

3.Phytochemistry Overview:

Numerous sections of Moringa oleifera as well as its isolated synthetic chemicals have been the subject of extensive research. The Moringa genus is proud to have identified more than 90 substances with substantial medicinal promise. Proteins and amino acids, phenolic acids, carotenoids, alkaloids, glucosinolates, flavonoids, sterols, terpenes, tannins, saponins, fatty acids, glycosides, and polysaccharides are only a few of the many different types of these isolated manmade substances (Masarkar, Paikar and Krawczyk, 2017,2022 and 2023).

Moringa oleifera leaves, in particular, exhibit a notable concentration of phenolic acids such as cinnamic acids, Sinapic acid, syringic acid, gentisic acid, gallic acid, ferulic acid, protocatechuic acid, vanillin, caffeic acid, o-coumaric acid, p-coumaric acid, and epicatechin are present, while flavonoids including quercetin, catechin, myricetin, and kaempferol demonstrate excellent therapeutic activity (Paikra et al., 2017).

The photochemistry of Moringa oleifera, particularly its bioactive components like phenolic compounds, flavonoids, carotenoids, and oils, suggests that the plant may have significant photoprotective properties. Its potential for use in cosmetics and health supplements, especially in the context of light-induced skin damage and oxidative stress, makes it a promising candidate for further photochemical and pharmacological studies.

4.Pharmacological activities:

4.1. Antimicrobial and antifungal activity:

Rich in bioactive components, moringa has the ability to prevent the growth of harmful bacteria Flavonoids,

saponins, steroids, terpenoids, and tannins are examples of antimicrobial components found in plants. An antibiotic molecule called pterygospermine, which is extracted from flowers, has strong antibacterial qualities (Jayasri et al., 2021). Root extracts of moringa adversely affect the growth of E. coil, p. aeruginosa, and S. aureus bacteria. The fresh leaves of M. Oleifera, in both juice and hydroalcoholic extracts, exhibit antimicrobial potential against both Gram-negative and Gram-positive bacteria (Sharma and Anzano, 2020 and 2022). Additionally, alcoholic extracts have biological action against candida albicans. Methanolic extracts dramatically stop the development of Trichoderma harzianum and the fungus Aspergillus nidulans, have been shown to be suppressed by extracts of M. Oleifera leaves, seeds and stems. Alkaloids, flavonoids, and steroids found in M. Oleifera fruits prevent candida albicans growth by either denaturing proteins or preventing spore germination through the steroids ring. 20 Moringa seed kernel extract is less effective against P. aeruginosa and E. coil, but it has significant inhibitory effects against Bacillus cereus, Staphylococcus aureus, Mucor species, and Aspergillus species. A single extract from M. Oleifera seeds exhibits antibacterial activity against Gram-positive bacteria, according to a recent study (Anzano and Dinesha, 2018 and 2022).

4.2 . Anti-inflammatory activity: Anti

Various components of M. oleifera, including leaves, pods, flowers, and roots, demonstrated a noteworthy anti-inflammatory effect. Specifically, an isolated compound, 4-[2-o-Acetyl-alpha-l-rahamnoslyloxy) benzyl] thiocynate from Moringa, exhibited inhibitory activity on nitric oxide and proved effective in Raw264.7. The study explores the anti-inflammatory properties of the Moringa oleifera ethyl acetate fraction in RAW264.7 cells. It found that the fraction downregulated iNOS, COX-2, and NF-kB expression, while increasing IkBα levels. This suggests a potential therapeutic avenue, as agents that disrupt NF-kB activation have shown efficacy in treating inflammation associated diseases. The study also found that the ethyl acetate fraction's anti-inflammatory potential is linked to suppressing NF-kB activation, preventing IkBα degradation and NF-kB p65 protein translocation (Park et al., 2011). the anti-inflammatory effects of Moringa in a colitis model (a type of inflammatory bowel disease). The study found that Moringa supplementation reduced inflammatory markers, improved gut integrity, and suppressed the NF-κB pathway, suggesting its potential therapeutic role in gastrointestinal inflammation (Kumar et al., 2021). The effects of Moringa leaf extract in asthma models and observed significant reductions in airway inflammation and bronchoconstriction. The study showed that Moringa reduced the levels of inflammatory cytokines such as IL-4 and IL-5, which are involved in allergic asthma and inflammation. (Sahu et al., 2019). The anti-inflammatory effects of Moringa in chronic inflammation and oxidative stress. The study showed that Moringa significantly reduced levels of pro-inflammatory cytokines and oxidative markers, making it a potential natural therapeutic for chronic inflammatory conditions (Alam et al., 2019).

4.3 . Neuroprotective and antioxidant effect in neurodegenerative disorders:

Moringa is recognized for its neuroprotective effects, attributed to its ability to enhance blood supply to the brain. This is crucial in preventing cerebral ischemia and reducing the ROS formation. The plant significantly reduces ROS, inducing an antioxidant response that protects the brain. Notably, Moringa reduces brain infarct volume in cortical and subcortical areas significantly (Kirisattayakul et al., 2013). Moringa is rich in antioxidants, including flavonoids like quercetin, kaempferol, and isothiocyanates, as well as phenolic compounds and ascorbic acid (vitamin C). These compounds help to neutralize reactive oxygen species (ROS) and reduce oxidative stress, which is a major contributor to neurodegenerative diseases such as Alzheimer's and Parkinson's disease (Akinmoladun et al., 2017). Chronic inflammation in the brain is a hallmark of many neurodegenerative diseases. Moringa's ability to modulate inflammatory pathways, particularly through the inhibition of pro-inflammatory cytokines (e.g., TNF-α, IL-1β, IL-6) and the NF-κB signaling pathway, is another critical mechanism through which it may exert neuroprotective effects (Bamidele et al., 2020). Alzheimer's disease is characterized by the accumulation of amyloid-beta plaques, oxidative stress, and neuroinflammation. Moringa's antioxidant and anti-inflammatory properties have been investigated for their potential to slow the progression of AD (Akinmoladun et al., 2017). Parkinson's disease is characterized by the degeneration of dopaminergic neurons, and oxidative stress plays a significant role in this process. Moringa's antioxidant and anti-inflammatory properties may help mitigate some of the damage associated with PD (Bamidele et al., 2020). Moringa's neuroprotective effects have also been investigated in relation to other neurodegenerative disorders like Huntington's disease and multiple sclerosis. For Huntington's disease (HD), Moringa treatment preserves normal parameters and prevents the elevation of glutamate and dopamine levels observed in the HD group. However, its

effectiveness is limited against specific induced demyelination and protein aggregations in certain brain areas of the HD rodent model (Akinpelu et al., 2019).

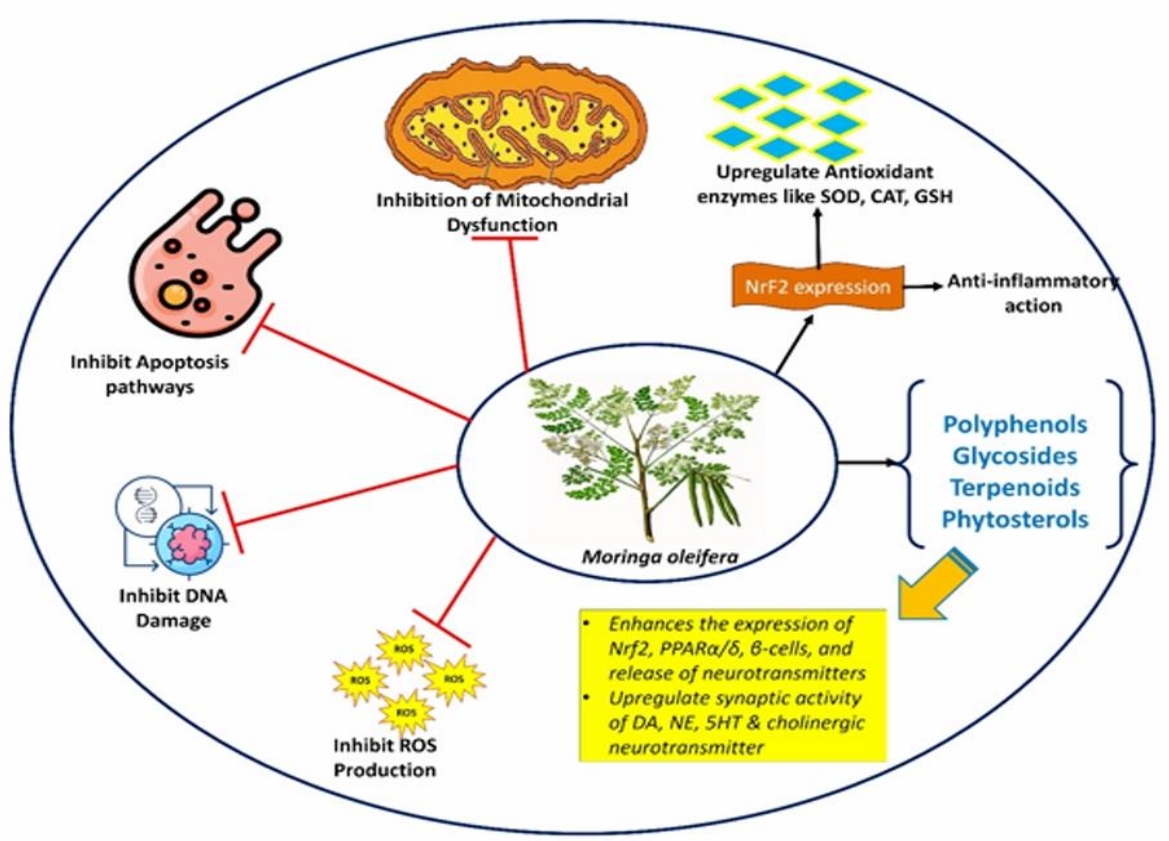

Figure 2: Neuroprotective mechanism of moringa oleifera

Neuronal degeneration is a significant contributor to oxidative stress, a leading factor in neurological disorders like mitochondrial dysfunction. Mitochondria, vital for cellular functions such as energy metabolism, synthesis regulation, ATP production, and ROS scavenging, become dysfunctional in various neurodegenerative disorders. Non mitochondrial ROS generation leads to mitochondrial ROS and disrupts chelation balance within cells (Doke et al., 2019). The study conducted by Muhammed et al. in 2020 revealed that Moringa exerted a protective influence against mitochondrial dysfunction by modulating the activities of mitochondrial nicotinamide adenine dinucleotide (NADH) dehydrogenase and ATPase enzymes. This underscores the plant's intrinsic neuroprotective activity, which plays a key role in averting ROS generation and mitigating oxidative damage (Muhammed et al., 2020).

4.4. Antidiabetic Activity:

Moringa leaves exhibited notable efficacy in augmenting glucose tolerance in Wistar and Goto-Kakizaki rats, concurrently eliciting a reduction in blood glucose levels. The aqueous extract demonstrated pronounced antidiabetic effects by modulating key parameters, including blood glucose levels, protein, sugar, and haemoglobin, in rat models (Sena et al., 2007). Moringa oleifera has been shown to improve insulin sensitivity and enhance insulin secretion. Some studies suggest that Moringa leaf extracts can help in reducing blood glucose levels by improving the body's response to insulin, potentially benefiting individuals with Type 2 diabetes. Moringa is rich in antioxidants like vitamin C, flavonoids, and phenolic compounds. These antioxidants help in reducing oxidative stress, which is a contributing factor in the development and progression of diabetes. The antioxidant properties may help protect pancreatic β-cells, which are responsible for insulin secretion, from damage. The antidiabetic potential of Moringa leaf powder in streptozotocin-induced diabetic rats. The study found that Moringa leaf powder significantly reduced blood glucose levels and improved lipid profiles, demonstrating its potential as a therapeutic agent in managing diabetes (Faizi et al., 2010). The effects of Moringa leaf extract on blood

glucose levels in human diabetic subjects. The study found that taking Moringa leaf powder as a supplement significantly reduced fasting blood glucose and improved overall glycemic control (Jaiswal et al., 2012). The hypoglycemic effect of Moringa seed extracts in diabetic rats. The results showed that Moringa seed extracts significantly reduced blood glucose levels and could potentially serve as an adjunct to existing diabetes treatments (Shuaib et al., 2015).

4.5. Anticancer activity:

Cancer is a major cause of death globally and the second leading cause of death in the United States. Several epidemiological studies have found a link between cruciferous vegetable consumption and an increased risk of developing breast, lung, and colon cancer (Boggs et al., 2010). Extracts from M. oleifera's leaves and bark inhibit the formation of tumours in colorectal, breast, and pancreatic cancer cells. Alsamari and associates performed an analysis using gas chromatography and mass spectroscopy, discovering 12 different chemicals in the extract of M. oleifera, three of which may have anticancer effects (Fowke et al., 2003). The powerful anticancer compound's precursor form the whole plant naturally contains glucosinolates and isothiocyanates (Fahey et al., 2001). Extensive research has focused on their anticancer efficacy, revealing that both androgen-dependent and androgen-independent human prostate cancer cells are inhibited in development by allyl isothiocyanates. When benzyl isothiocyanates were administered to mice harboring BxPC-3 tumor xenografts, it shows a significant 43% decrease in tumor development. By blocking AKT, phenyethyl isothiocyanates have shown promise in slowing the progression of cancer (Xiao et al., 2003).

4.6. Analgesic/antipyretic activity:

Numerous pre-clinical investigations on rats have documented the analgesic and anti-inflammatory properties of Moringa, and it has been suggested that Moringa reduces inflammatory indicators. An alcoholic extract of moringa seed and leaves showed a comparative analgesic efficacy between aspirin and indomethacin (Mabrok et al., 2019). Moringa's anti-inflammmatory active ingredients include vanillin, hydroxymellein, moringine, moringinine, sitostenone, and 9-octadecenoic acid. Experimental albino rats demonstrated the antipyretic efficacy of moringa leaf extract, which reduced yeast-induced pyrexia and, in a dose-dependent manner, kept the body temperature at a normal level. In experimental albino rats, moringa leaf extract was demonstrated to be a highly effective antipyretic by considerably lowering yeast-induced fever. Additionally, the extract demonstrated a dose-dependent response, successfully preserving the test participants' normal body temperature (Pandey et al., 2012).

4.7. Hepatoprotective:

M. oleifera's hepatoprotective activity is associated to the abundance of bioactive substances found in its aqueous leaf extracts, which include high quantities of phytochemicals such as flavonoids, phenolic acids, and carotenoids. These chemicals work together to provide therapeutic effect and for its possible health advantages, M. oleifera should be consumed on a daily basis.52 However, excessive intake may lead to iron accumulation, causing gastrointestinal distress and hemochromatosis. To prevent nutrient over accumulation, a daily dose of 70 g of M. oleifera is suggested (Pagadala et al., 2020). The antioxidant-rich characteristics of M. oleifera aqueous leaf extract are demonstrated in in vivo experiments, and this is an important defense against illnesses brought on by oxidative stress. The hepatoprotective properties of M. oleifera against oxidative stress are remarkable. M. oleifera's antioxidant action reacts to elevated ROS. M. oleifera releases Nrf2 via activating the Nrf2-Keap1 complex in the presence of oxidative stress. Antioxidant response elements (ARE) are bound by the phosphorylated version of Nrf2 (p-Nrf2), which then translocates to the nucleus and stimulates the transcription of antioxidant genes. By upregulating antioxidants and downregulating ROS, this cascade efficiently reduces oxidative stress (Kim et al., 2022).

CONCLUSION:

Moringa oleifera, the "Miracle Tree," is a multifaceted plant that has demonstrated exceptional nutritional, medicinal, and environmental benefits. Its rich antioxidant profile, anti-inflammatory properties, and potential to address various health concerns make it an invaluable resource for promoting human health, wellness, and sustainability. Nutritional powerhouse rich in vitamins, minerals, and essential amino acids. Medicinal properties: anti-inflammatory, antimicrobial, anticancer, and cardiovascular protective effects. Therapeutic applications manages diabetes, hypertension, digestive issues, and skin conditions. Environmental benefits drought-tolerant, soil conservation, and biodiversity promotion. Economic potential sustainable food source, livestock feed, and cosmetics ingredient.

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